INSTRUCTION MANUAL

NO. IN 1211.3-8
(Formerly 6410)

BARBER COLMAN

Capacitrols

model 410P

Effective for Models starting with
Serial No. 36F780

MP MASTER
MA32120

BARBER-COLMAN COMPANY
Industrial Instruments Division

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NOTE: This instruction manual to be given to persons responsible for installation and maintenance of this instrument.

GENERAL DESCRIPTION

The Model 410P CAPACITROL is a millivoltmeter type indicating controller, producing a stepless — proportioning output current. The output will vary, when in the proportioning band, from a maximum of approximately 17 volts DC down to 0.5 volts or less.

The intended application of the Model 410P is that it be used in combination with any of the Barber-Colman three-function magnetic modulator devices. These are designated as the MMC (current output), MMP (position type), and MMD (duration type). Used in any of these combinations, the instrument is capable of a high degree of reproducibility and fast response where close control of the process is critical. These three function controllers retain the stability of proportional control, the ability to eliminate offset or "droop" because of automatic reset, and the ability to provide a much faster correction due to rate control. In addition, the effective proportioning band of the Model 410P becomes adjustable over a much wider range due to the MM series controllers.

UNPACKING INSTRUMENT

This precision instrument and its associated equipment have been carefully manufactured and packed at the factory. Remove the instrument and accessories carefully from the packing box when delivered, and check items with the packing slip. If the equipment is found to be damaged in transit, report the extent of damage to the carrier immediately. Repack in original packing box until ready for installation.

CAUTION:

Handle with care.
Before and after installation:
Safeguard instrument from shock.
Avoid exposure to moisture.
Keep instrument temperature under 130°F.

MOUNTING INSTRUCTIONS

Locate the instrument to avoid shock, excessive vibration, moisture and temperatures over 130°F. Avoid furnace walls, radiation of heat, machine frames and outside walls. Provide suitable shelter to avoid moisture and temperature extremes if installed outdoors.

For surface mounting, attach the three lugs (provided) to the back of the instrument housing. See the surface mounting dimension drawing.

For flush or panel mounting, remove the angle brackets from the cloth bag, insert the instrument through the panel opening, attach brackets to the side of the instrument housing and tighten firmly. See the flush mounting dimension drawing.

MOUNTING DIMENSIONS

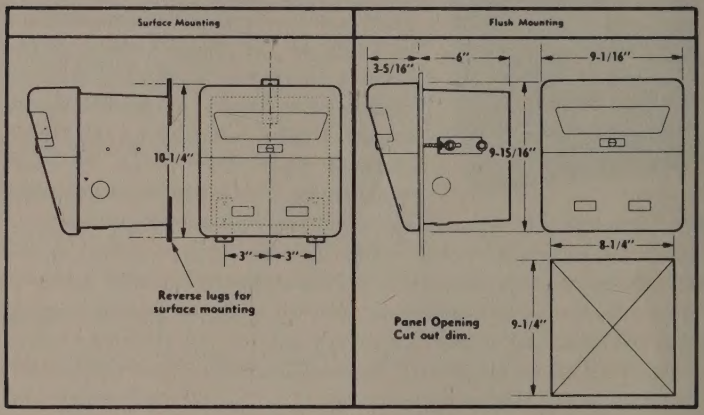


FIGURE 1
Standard flush and surface mounting dimensions

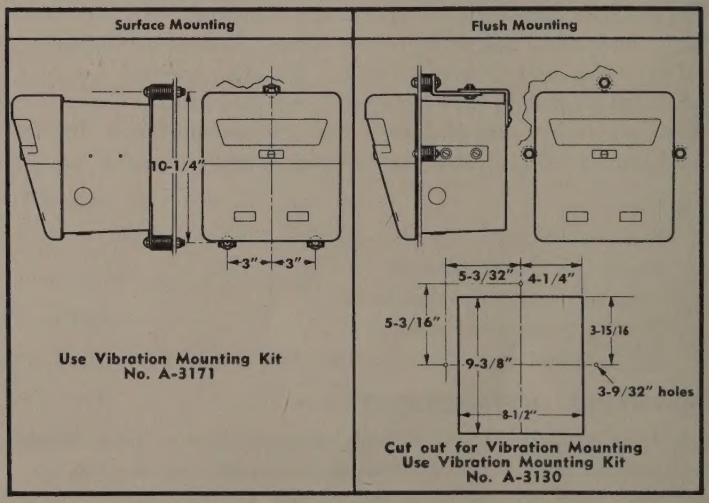


FIGURE 2
Special vibration mountings

The MM Series control unit is mounted separately but as near the Model 410P as desired for convenient wiring. The Pilot Amplifier, if used, must be mounted in an upright position unless the small percentage meter supplied with it is mounted externally. It is recommended that the Pilot Amplifier and MM Series Controller be located away from excessive vibration and heat. The ambient temperature should not exceed 130°F.

Further details for the mounting of accessory equipment will be found in the instruction sheets shipped with the equipment.

POWER WIRING

Before connecting power to this instrument, check the supply voltage and frequency with the nameplate ratings on the control chassis. The supply voltage and frequency data are found on the chassis front. Connect supply to L1 and L2. Run all wiring in rigid conduit, BX or Greenfield in accordance with the recommended electrical code. Tighten the binding screws on the instrument terminal board so as to secure the wires permanently. No. 14 gauge solid wire is recommended for wiring to instrument, and throughout the rest of the control circuit. If stranded wire is used, tin ends to provide secure terminal connections. Be certain that the wires are placed to not interfere with chassis insertion nor housing front. Ground the instrument case, or make certain conduit system is properly grounded. Do not run thermocouple leads with any power or control wiring.

To alter the control chassis in the field for different line voltages, change the transformer primary connections in the chassis per the following:

240 VOLT Solder red wire to chassis pin 12 (L1), green-yellow wire to chassis pin 10 (L2). Solder green wire to red-white wire and tape connection.

120 VOLT Solder red and green wires to chassis pin 12 (L1). Solder red-white and green-yellow wires to chassis pin 10 (L2). See internal wiring diagram page 22.

THERMOCOUPLE WIRING

Use only extension lead wire correct for the type of thermocouple (TC) as specified on the scale. The most commonly used types are: Iron-Constantan (I/C or Type J), Chromel-Alumel (C/A or Type K), Platinum-Platinum 10% Rhodium (Pt/Pt 10% Rh or Type S), Platinum-Platinum 13% Rhodium (Pt/Pt 13% Rh or Type R), and Heat-Eye. Ordinary copper wire will NOT serve the purpose, except for use with radiation detectors which are compensated internally for lead wire

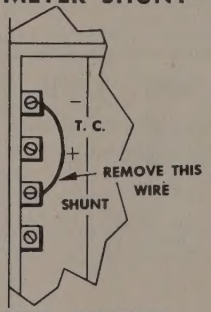
resistance. The measuring circuit system is normally designed for an external resistance of 15 ohms (check scale). 15 ohms is usually ample resistance for most lead wire runs. Find resistance of lead wire and subtract from specified external resistance as found on scale. The remaining resistance must be inserted internally by means of a removable resistance strip found in the chassis compartment. This compensating resistor strip is furnished on all original installations. Other values can be obtained at a nominal cost.

Proper polarity (plus) and (minus) of the lead wire must be observed to obtain correct readings. In case of splicing the lead wire (splicing is not recommended) use soldered connections, and splice plus to plus, and minus to minus.

The negative TC lead wire is always coded red. Correct polarity can be checked by heating a temporary junction of the lead wire at the far end to deflect the meter upscale. When connected with a thermocouple, the proper lead wire connections are necessary for obtaining correct readings. Wrong polarity of the lead wire causes low readings of varying amounts, depending on temperatures at the junction points. If the meter reads backward with the TC connected, reverse the connections at the thermocouple head, since the lead wire polarity has previously been checked for correctness.

Locate the lead wire away from the chassis socket strip and housing gaskets.

METER SHUNT WIRE



After the instrument is installed, remove the jumper wire from between terminals "S" and "T.C. -".

This wire is used to short out the meter movement for shipping purposes only and should be replaced when shipping the instrument to prevent damage to meter. Avoid placing wires in the chassis compartment that may interfere with the chassis or gasketed cover.

TCB WIRING

The instrument is equipped with thermocouple break (TCB) protection. Essentially it is a small DC voltage that can be wired into the thermocouple circuit to drive the movement upscale in case of an open circuit in the thermocouple, thus passing the control set point and causing the instrument control to go to the off position. It is not necessary to make the TCB connections for normal operation of the instrument, but its use may be desirable on some applications to guard against overheating in event of an open thermocouple.

The preferred method of connecting TCB is shown in Fig. 3. Use extension lead wire as required to make the connections between the instrument T/C terminals and the thermocouple head. Use 14 gauge copper wire to connect the TCB terminals to the thermocouple head, observing polarity. Wiring for TCB may be run in the same conduit with thermocouple lead wire. As the resistance of the thermocouple is low compared to the resistance of the meter movement, TCB compensation is seldom required.

Although not recommended, an optional method of connecting TCB is to use jumpers at the instrument terminals as shown in Fig. 4. As the length of lead wire used affects the amount of TCB compensation required, it is suggested that this method be used only with short lead wire lengths, 10 ft. or less and that the amount of TCB error be checked.

To check for TCB operation, disconnect the thermocouple to simulate a broken thermocouple but leave the TCB wires connected to the lead wire. When the instrument is powered, the indicator should drive upscale above the red control set pointer to cause the control to go to the off position.

Do not connect TCB when instrument is used in conjunction wtih a radiation detector, or with a Model 350 Reference Voltage Source. See Model 350 Instruction Manual for complete instructions.

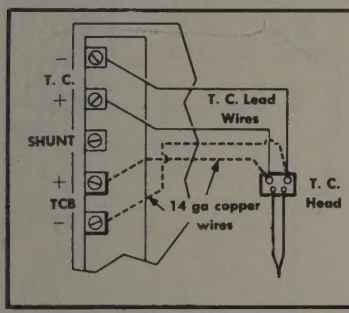


FIGURE 3

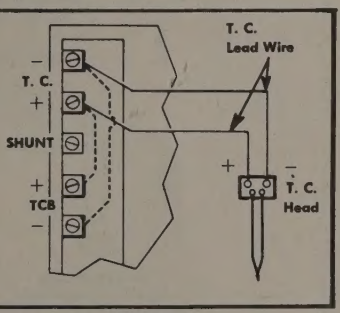
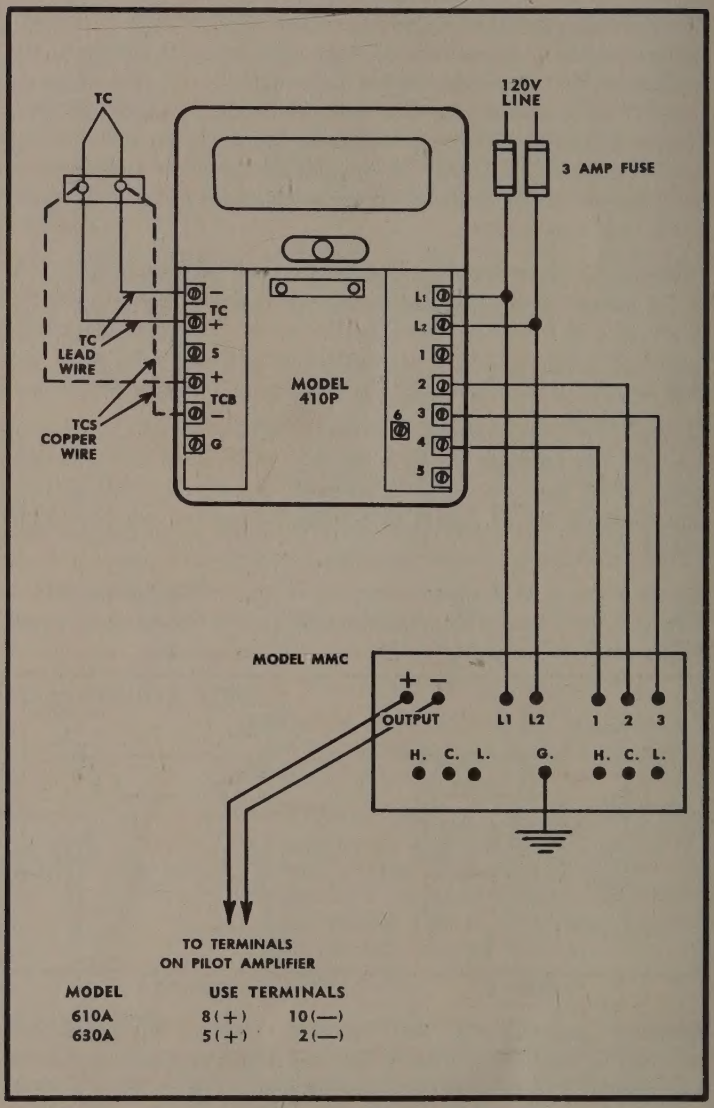


FIGURE 4

Caution: Inasmuch as the MMP and MMD require a negative increase in power to "turn on" or increase fuel (see section on Electronic Circuit Description), it is possible that a malfunction or power failure in 410P unit could cause the MMP or MMD to call for maximum power. It is definitely recommended that additional safety equipment such as Model 711L Limitrol be used to safeguard equipment and material when using MMP and MMD with the Model 410P unit. The MMC is inherently failsafe due to increasing signal necessary to obtain MMC output.

EXTERNAL WIRING DIAGRAM

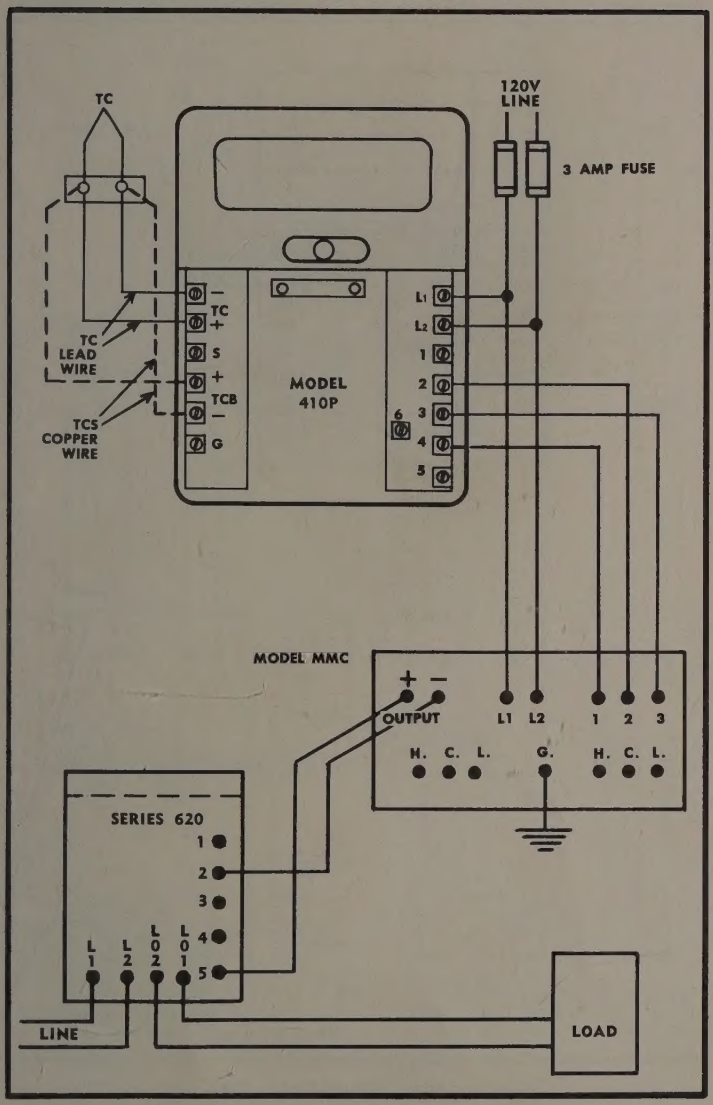


MODEL	USE TERMINALS	
610A	8(+)	10(—)
630A	5(+)	2(—)

Model 410P with Model MMC and Pilot Amplifier for Current Output Type of Control

NOTE: The output of the Model 410P, from these terminals, decreases on temperature rise after entering the proportioning band.

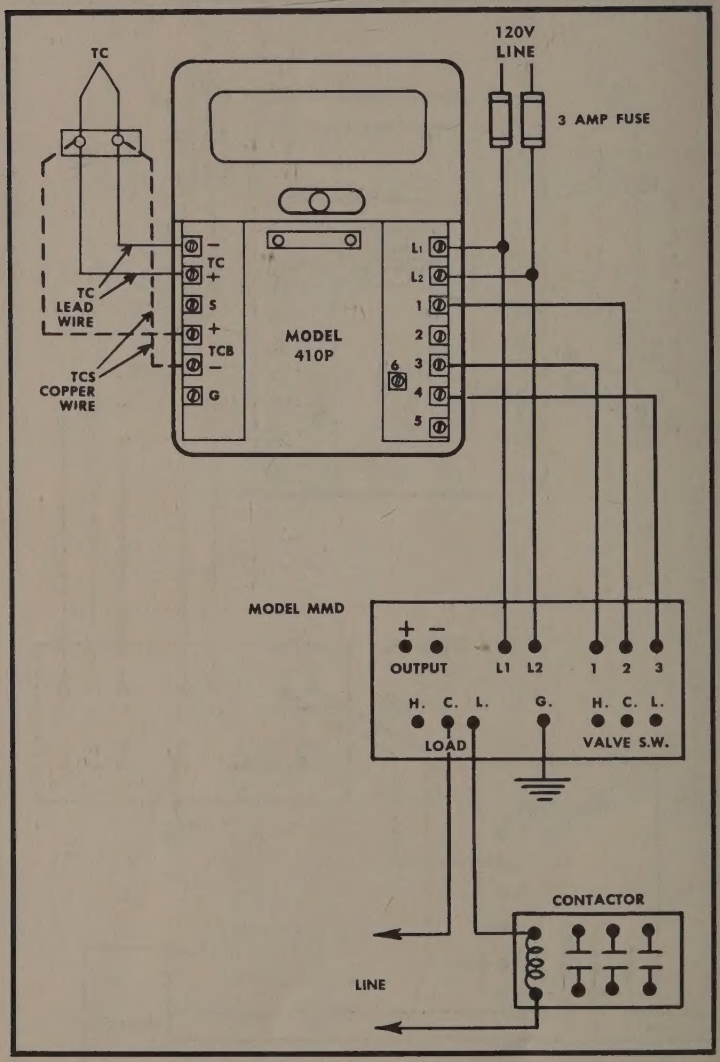
EXTERNAL WIRING DIAGRAM



Model 410P with Model MMC and Series 620 Power Controller for Current Output Control

NOTE: The output of the Model 410P, from these terminals, decreases on temperature rise after entering the proportioning band.

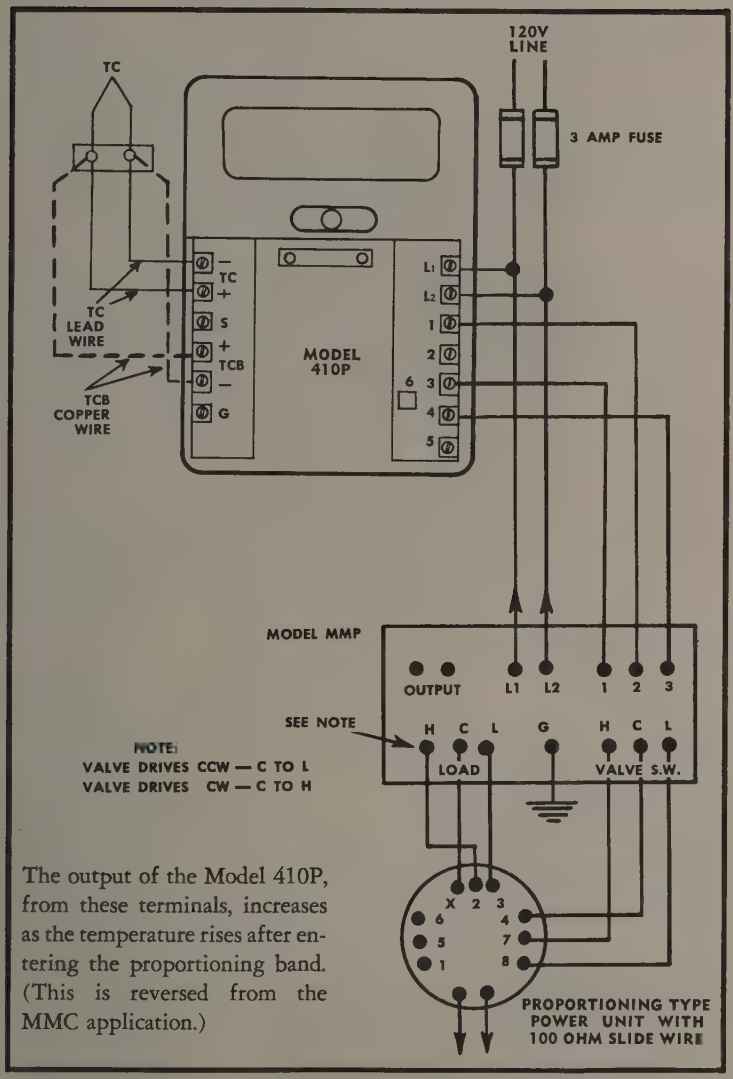
EXTERNAL WIRING DIAGRAM



Model 410P with Model MMD for Duration Type Control of Electrical Input Contactor

NOTE: From these terminals, the output of the Model 410P increases on temperature rise after entering the proportioning band. (This is reversed from the MMC application.)

EXTERNAL WIRING DIAGRAM


120V LINE
3 AMP FUSE
TC
TC LEAD WIRE
TCB COPPER WIRE
MODEL 410P
MODEL MMP
OUTPUT
L1 L2 1 2 3
SEE NOTE
H C L G H C L
LOAD
VALVE S.W.
NOTE:
VALVE DRIVES CCW — C TO L
VALVE DRIVES CW — C TO H
The output of the Model 410P, from these terminals, increases as the temperature rises after entering the proportioning band. (This is reversed from the MMC application.)
PROPORTIONING TYPE POWER UNIT WITH 100 OHM SLIDE WIRE

Model 410P with Model MMP for Position Type Control of Barber-Colman Proportioning Type Power Unit

As shown, power unit will rotate counterclockwise for increased heat input. For clockwise position, interchange terminals 2 and 3, also 7 and 8 on the terminal strip of the power unit.

METER ADJUSTMENTS AND CHECKS

The indicating pointer should come to rest at the ambient temperature when the lead wire and TCB is disconnected at the instrument. Use a thermometer as close as possible to the TC terminals in the instrument to determine the ambient temperature. This is called the cold junction reading since the lead wire, in effect, extends the thermocouple to the TC terminals of the instrument.

If the indicating pointer does not come to rest at the ambient temperature, slowly turn the adjusting screw, located at the top of the case, to give proper reading. Further deflection as the ambient temperature changes is automatic, since the meter has automatic cold junction compensation.

For temperature scale calibration follow instructions F-6434, using Model 330 portable potentiometer.

It is seldom necessary to compensate for TCB, which may cause the meter to read insignificantly high when the instrument is powered. It is not necessary where the thermocouple itself has the usual near-zero resistance. Should it be desired to compensate for this upscale deviation, it may be done by shifting the reading downscale to correspond to the TCB effect as explained below:

With the instrument previously adjusted for correct ambient temperature, the thermocouple should be held at a steady temperature while observing the difference in meter readings with the instrument powered and unpowered. If the difference is discernable, compensation may be made with the zero adjusting screw in order to lower the indicating reading, with the instrument powered, to the same point of deflection observed when the power was off. The cold junction or ambient adjustment is thereby changed downscale by this same corrective deflection. An alternate method to make this check is by making and breaking the TCB circuit, rather than through off-on power to the instrument.

DESCRIPTION OF ELECTRONIC CIRCUIT — MODEL 410P

The Model 410P is an extension of the basic 400 series control family. The familiar Electronic Link principle is incorporated here to sense the position of the meter pointer in respect to the control set point. Unlike the other instruments in the 400 series, the Model 410P chassis employs a two stage oscillator — amplifier circuit with a *reversed* tuned grid — tuned cathode oscillator, as a means of obtaining correct output action for the MM series controllers.

When the vane, carried by the temperature pointer, passes upscale between the pick-up coils mounted on the set point arm, the oscillator section of the circuit goes out of oscillation, causing the amplifier section not to conduct. (The amplifier section of the 12AU7 electronic tube is a resistance coupled cathode follower operating from the output of the oscillator section.) At this position of the pointer vane, the output of the oscillator section is maximum, though negative, and the amplifier output is minimum and positive.

The reverse is also true that when the temperature pointer is downscale well below the control set point — that is, with the vane out of the pick-up coils, the oscillator section is caused to oscillate and permits the amplifier to conduct. This time the output of the oscillator section is minimum, though less *negative,* and output of the amplifier is maximum and positive.

The purpose of this circuit design is to provide proper input characteristics to the MM Series controllers. (See section under MM Series Controllers). Figure 5 shows diagramatically the electronic tube output in its two sections as supplied to the MM controllers.

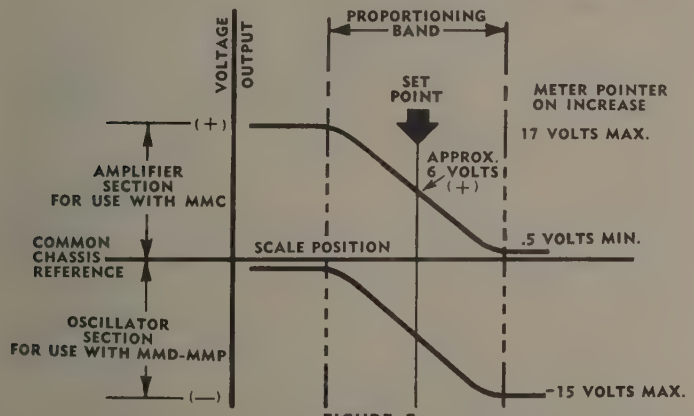


FIGURE 5

The electron tube output is controlled between one-half volt DC minimum output, to 17 volts maximum (positive) in the amplifier section, and from 2 volts to 15 volts (negative) in the oscillator section. The output at any time depends upon flag position and section of circuit measured. These voltages are conveniently measured at the three test jacks on front of the plug-in chassis.

NOTE: Use a voltmeter of 10,000 ohms per volt sensitivity for this test. See diagram on page 22.

INSTRUMENT CONTROLS

The Model 410P provides manual adjustments for control set point, proportioning band and control tuning (or reset). A green signal lamp indicates when the instrument is powered.

The *control point setting knob* is located directly beneath the instrument scale. It is easily turned by hand but is recessed for protection against accidental shifting. The *proportioning band* width, or throttling range, is adjusted by positioning a dial knob located on the left front of the instrument chassis and marked MAX-MIN. The band is narrowed when turning the knob clockwise and widened when turned counterclockwise. The *tuning capacitor adjusting screw,* labeled RESET, is located on the right front of the chassis. This adjustment may be needed to produce the correct voltage output, at a given proportioning band setting, to feed into the MM controller.

Proportioning band and reset adjustment on the Model 410P are made only prior to start-up of the system. Further adjustment of these functions are made on the MM Series Controller. Refer to CONTROL ADJUSTMENTS PRIOR TO STARTUP.

MM SERIES CONTROLLERS — GENERAL

Used in conjunction with the Model 410P, the MM Series controllers are three-function — providing proportional plus reset plus rate control, and each with separate and extensive adjustment. These controllers make it possible to maintain a process continuously at the desired value. Even when a disturbance occurs, causing excessive deviation of the controlled variable, a quick return to the set point will follow.

The MMC is a *current* type of three-function controller used to control a variety of devices. The final control element may be a silicon controlled rectifier power controller or a saturable reactor. When the saturable reactor is used, a pilot amplifier (such as the Model 610A or 630A) is usually necessary for intermediate power amplification. The use of the MMC in the circuit ahead of these control elements makes available its features of automatic rate and reset action, integrated with the stepless proportioning control from the Model 410P.

Used as a *position* type of controller, the "MMP" relay action determines the rotation and positioning of a valve, or the actuating of a valve positioning device, in controlling fuel output. Normally a Barber-Colman Type MP Power Unit is used as the final control operator.

The MMD or *duration* type three-function controller, uses its output to regulate the duration, or on-time, of an electrical input contactor, or the full open interval of a motor operated or solenoid operated valve. This achieves a pulsing type of control action when the meter is in the proportioning band.

MM CONTROLLERS— ELECTRONIC CIRCUIT DESCRIPTION

NOTE: For a more extensive description of the MM controllers, refer to the particular instruction manual supplied. The brief statements here describe only their action as adapted to the Model 410P.

The magnetic modulator receives a DC signal from the Model 410P, adds automatic reset for droop correction, and automatic compensation for rate of approach with any deviation from control point. Whenever the indicator pointer of the Capacitrol is not at coincision with the set point, the difference in output voltage, from that produced at set point, creates an unbalance in the modulator network. Briefly stated, the modulator adds or subtracts this amount of difference, amplifies the result, feeds it to a phase detector circuit, and through appropriate output circuits, corrects the power output to the final control element.

CAUTION: For installations using the MMP or MMD Series controllers, make certain that the MM controller is never left powered with the Model 410P unpowered, or permit any circumstance that could create a prolonged zero output from the Model 410P (such as a malfunctioning). Such condition may cause the furnace to turn on and possibly reach an excessive temperature.

SCR POWER CONTROLLERS

Barber-Colman Series 620 Power Controllers are final control devices of small physical size but capable of controlling up to 10 KVA* of AC power to a furnace or other electric load. The low voltage control signal required by the power controller permits it to be driven directly from the MMC, thereby eliminating the intermediate pilot amplifier.

The Series 620 Power Controllers incorporate two semi-conductors known as silicon controlled rectifiers. These are arranged with suitable firing circuitry so that they will regulate the amount of ON versus OFF time (within each half cycle of the AC load current) proportional to the value of the DC control signal input. For a complete discussion of these models, request Educational and Application Guide No. ED 1412-1.

* Will be increased later date.

PILOT AMPLIFIERS AND REACTORS

A pilot amplifier of the magnetic type (Model 610A), or the silicon controlled rectifier type (Model 630A), is connected between the MMC and a saturable core reactor. The amplifier receives the small DC output current from the controller, and makes available a much larger (approximately 180 times) current needed to saturate the magnetic core of the load current reactor. The reactor is essentially a large choke coil with a DC control winding wound on the iron core along with the AC windings. Direct current, passing through the control windings, saturates the iron thereby reducing the inductive effect of the AC, and permits a much greater alternating current to flow. The amount of current flow in the load winding is proportional to the DC in the control winding.

Pilot amplifiers available are:

Model 610A Magnetic Amplifier, 120 V. 60 cy., max. output 188 VA for reactors up to 30 KVA.

Model 630A, SCR DC unit, 120 V. 60 cy., 500 VA max. (4-75 VDC) for reactors of 30 KVA and up.

Model 630B, 240 V. 60 cy., 1000 VA max. 4-150 VDC.

Proper size reactors and pilot amplifiers are required to provide satisfactory maximum and minimum regulation of the current to the heating elements or other electrical load. Normally, there is some loss of line voltage through the reactor to the load, down to approximately 90 per cent of line voltage with the control output at maximum. The minimum control output is always greater than zero, but should cause the reactor to control at or below 17% of line voltage at the rated load.

REACTOR WIRING

For those installations using the Model 410P in combination with an MMC, Model 610A Pilot Amplifier and reactor, special attention is directed to the wiring of the reactor.

In the event that the external control circuit of the reactor should accidentally open while the reactor is under load, high voltage may be induced in the control winding. This could damage the internal insulation and result in a hazard. It is recommended that the shunting resistor always be connected between the terminals of the reactor control windings as shown in figure 6.

The load circuit of the reactor is connected in accordance with manufacturer's instructions accompanying the equipment, however, figures 6 and 7 show typical wiring schemes for single and three phase applications.

CONTROL ADJUSTMENTS PRIOR TO START-UP

Prior to initial start-up of the instrument system, the interaction of the proportioning band and reset should be checked. Completely wire together the Model 410P, MM Controller, and Pilot Amplifier (or valve, contactor or motor — depending on use of MMC, MMP or MMD), and attach the leads of a DC voltmeter to the test jacks of the Model 410P chassis. Apply power to the Model 410P chassis and MM Controller. Set the 410P proportioning band adjustment to "A" (maximum P.B.), and align the set point with the indicating pointer. The manual reset adjustment of the 410P should then be adjusted, if required, to obtain 5¾ ± ¼ volts. See page 22 for polarity. This is the point at which the output voltage should register 50% on the small meter on the MM Controller.

Once the correct output voltage is set, no further adjustment of the Model 410P proportioning band should be made. In fact, to do so would require a readjustment of reset as above. This setting of proportioning band, on "A" or MAX., is equivalent to approximately 5% of the scale. The total band width of the system, however, may be increased or decreased by using the proportioning band knob on the MM Controller.

610 A
UNDER 70Ω OVER 70Ω
1 2 3 4 5 6 7 8 9 10 11 12
NOTE: (1) Use load term. 3 and 4 if resistance of reactor d-c control winding resistance is between 30 and 70Ω. Use load term. 6 and 7 if resistance is between 70 and 150Ω.
NOTE: (2) Reactor a-c coils may be found to be parallel connected. Refer to mfgrs. spec. sheet accompanying reactor.
NOTE: (3) Identification of control winding terminals differ with various manufacturers.
TO D-C CONTROL WINDINGS OF REACTOR
SHUNT RES.
H1
H2
POWER REACTOR
LOAD
120 V. 60 CY.
3 AMP FUSES
+ −
OUTPUT L1 L2
INST. SW.
VALVE SW.
H C L
G H C L
MMC
FROM MODEL 410P
POWER SUPPLY

FIGURE 6

Figures 6 and 7 show typical wiring connections commonly used. Always refer to manufacturer's instructions accompanying reactor.

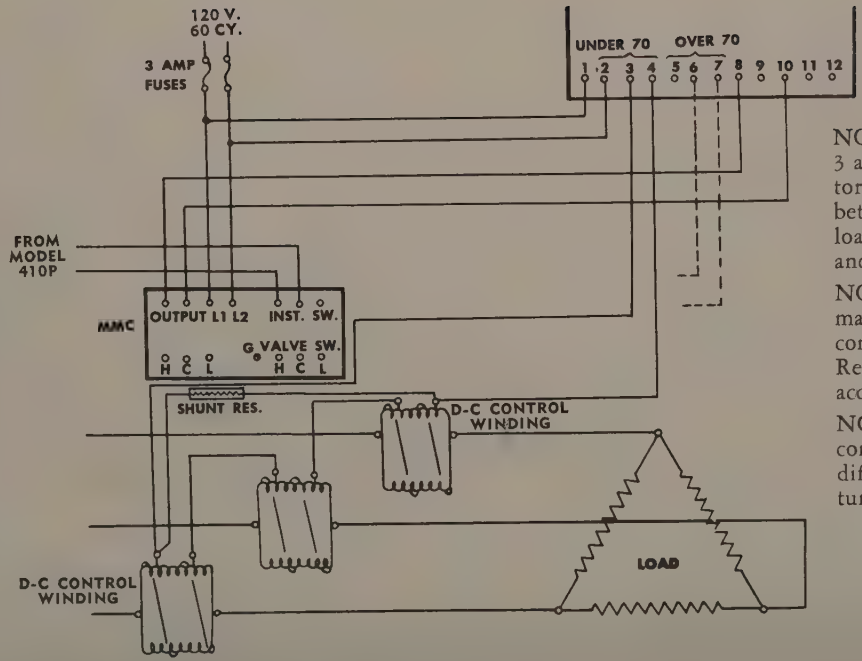


FIGURE 7

NOTE: (1) Use load term. 3 and 4 if resistance of reactor d-c control winding is between 30 and 70 Ω. Use load term. 6 and 7 if resistance is between 70 and 150 Ω.

NOTE: (2) Reactor d-c coils may be found to be parallel connected in special cases. Refer to mfgrs. spec. sheets accompanying reactor.

NOTE: (3) Identification of control winding terminals differ with various manufacturers.

At settings above 20% on the MM proportioning band dial, the total proportioning band will be increased above 5%; at setting below 20% the total band width will be reduced below 5%. The total proportioning band of the system, therefore, will not be as read on the MM graduated dial.

It should be noted that increasing the proportioning band with the MM adjustment to a point beyond the maximum obtainable from the Model 410P alone has the effect of reducing the maximum and increasing the minimum output voltage. This can be compensated by proper adjustment of reset on the MM series, which effectively restores the voltage to the full amount required for control.

In applications of fast response, where over-shooting must be held to a minimum on temperature rise from initial start-up, rate action may be introduced (eg., .1 on the graduated dial on the MM) together with a widened proportioning band. Widening the band permits rate action to be utilized earlier, since it is not effective until the indicating pointer moves into the proportioning band.

The Model 410P should be checked for ambient temperature with the thermocouple circuit disconnected. The Zero-Adjust should be set to allow the indicator pointer to come to rest at the ambient temperature as measured near the TC terminals of the Capacitrol. Further details of this procedure will be found in the section under Meter Adjustments.

TRIAL RUN ADJUSTMENTS

Before starting up the system, the instruction manual supplied with the MM Series Controller used with the Model 410P should be studied in order to gain familiarity with the components and operation of that instrument. It will be noted that the MM instruction manual makes reference to a potentiometer controller, usually referred to as a "recorder". Although this application was the intent of the original design, the instruction information is generally applicable to its use with the Model 410P. This is so because the Model 410P feeds an input voltage to the MM Controller which, when properly adjusted, duplicates the action of a potentiometer slidewire.

The MM Series instruction manual should be consulted for the procedure used for adjusting the output meter, balancing the controller, and checking the individual functions. These checks may be made to acquaint the user with these components or at any time their operation is questioned.

Procedures to place the instrument in operation, as outlined in the MM Series instruction manual, are the conventional methods for any three-function controller and may also be used when the Model 410P provides the input. An alternate method, found to be effective in more rapidly tuning the three functions of the controller to their approximate final settings, is as follows:

Set reset at zero
Set rate at zero
Set MM proportioning band at 30%

With the Model 410P proportioning band at MAX., turn power on to all systems. Observe the indicator pointer action as it comes up to set point. If the system lines out with approximate straight line control but with an offset, make a small upset (approximately 50F when operating around 1000F) and decrease the proportioning band on the MM Controller. The upset may be made by moving the set point slightly or by introducing a change in the process being controlled. Repeat this procedure until a controlled oscillation, or cycling, is obtained without dampening out into a different straight line offset.

Once the controlled oscillation is fixed, measure the time, in minutes, required for one complete cycle. Divide this time *into* 2½. The quotient is the approximate correct setting for reset. Rotate the reset knob on the MM to the nearest "repeats per minute" position less than this amount. Divide the cycle time in minutes *by* 2½. This figure will be the approximate rate setting. Multiply the MM Series PB setting, which produced the controlled oscillation, by 4½. This will give the approximate PB setting for that particular process. Insert these values of reset, rate and proportioning band into MM Controller, and the result should be very close to the desired control. Place an upset into the system again and observe control action. Be sure to allow sufficient time for the controls to stabilize. Make minor rate and reset adjustment, as may seem necessary, but without moving too far from the calculated settings and maintaining the approximate same relationships. Changes in the proportioning band should be infrequent, as this will require a readjustment of reset. The final point of band width adjustment will vary with furnace capacities and heat rates and must be determined for each individual installation.

With the correct adjustment of proportioning band, reset and rate, with respect to each other, the indicating pointer will be observed to approach the control set point at a decelerating rate following an upset. It will then come to rest at the set point, and hold with good stability until the next major control upset.

MODEL 410P
MAINTENANCE AND SERVICE CHECKS

While the 410P Series instrument is well designed and manufactured of high grade components, it is worthwhile to have information as to service and spare parts for emergency servicing. Where a number of instruments are located together, the plug-in parts are interchangeable and allow a minimum inventory.

Upon experiencing a trouble complaint, the serviceman should familiarize himself with the process and instrument application to ascertain the exact function of the instrument as applied. The instrument trouble usually can be traced to two basic problems, measurement or control.

Measurement trouble can be detected by observing the pointer position. If the measured temperature is known to be in error, check the following:

(1) Open thermocouple circuit, such as break in thermocouple or lead wiring.
(2) Deteriorated T.C. hot junction due to burning.
(3) Multiple shorts or grounds creating erroneous cold junctions.
(4) High resistance in leads due to loose connections, dirty switch contacts, poor splicing, and other faulty connections.
(5) Check for vibration or shock.

Control trouble may be detected by observing control point and indicated temperature position. If the temperature is not at the control point:

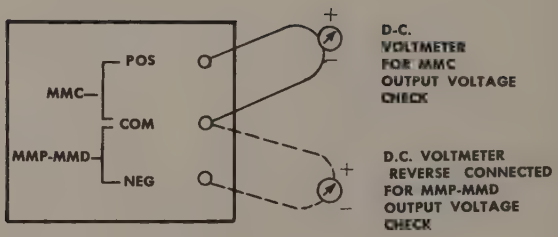
(1) Adjust manual reset to align pointers.
(2) If reactor is used:
Check power input for low maximums if temperature will not rise to control point.
Check power input for high minimums if temperature will not hold to control point. Minimum load voltage, 17% of line voltage. Is load matched to reactor size?
(3) Determine if instrument and pilot amplifier are powered; check load power for open circuits and open legs in three phase circuits.
(4) Determine if correct output potential is obtained. Measurement is conveniently made at the instrument by connecting a DC voltmeter to the applicable test jacks on the chassis as follows: (Refer to illustration on page 22).
When checking required output for an MMC hook-up, the testmeter should read between 11 and 17 volts DC, with the indicator pointer well below the red control set pointer. With the indicator above the red control pointer, (flag in the pick-up coils) the meter should read 2 volts or less.
For installations using an MMP or MMD, control action is reversed from the above. At an indicated temperature well below the control set point, a voltmeter placed across the test jacks will show the output to be in the range of from ½ to 2 Volts DC, depending on proportioning band setting. With the indicator well above the red set pointer (flag in pick-up coils), the output will increase to a maximum of 10 or 11 volts DC.
(5) Replace electronic tube.
If tube replacement does not give correction, other circuit defects are apparent.
(6) Replace chassis.
(7) Check for excessive vibrations.
(8) Measure supply for low voltages. Common low voltage to all components will cause large vibrations in available power to load.

For servicing of Magnetic Modulator (MM Series), or Series 620 Power Controller consult instruction manuals supplied with those units.

In event it is found necessary to remove the plug-in meter assembly, follow steps below.

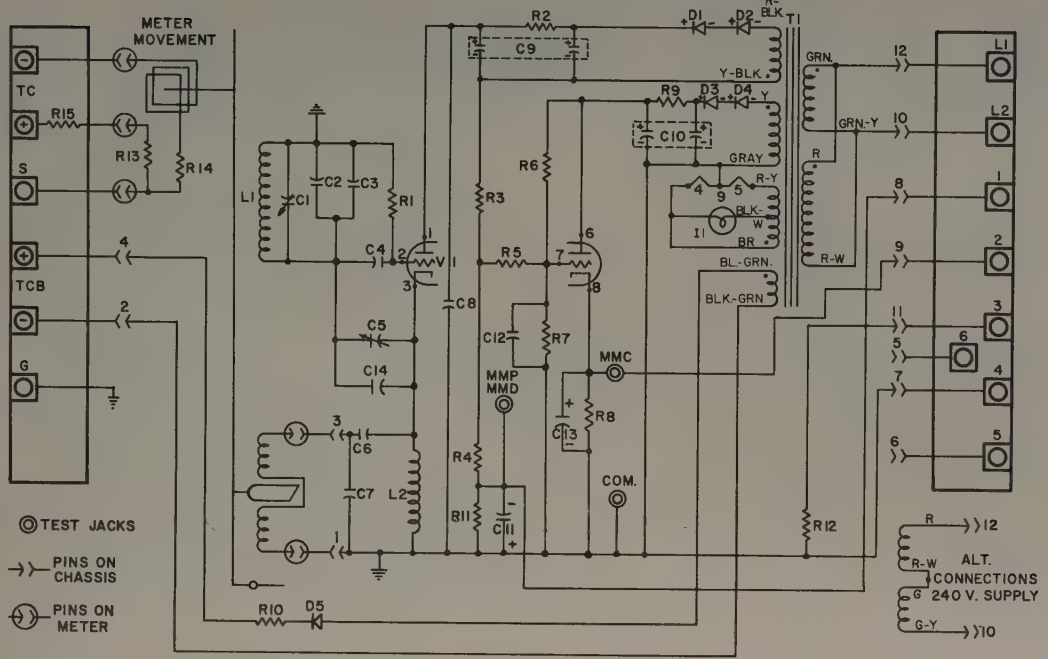
(1) Remove set point adjustment knob (Bristol No. 6 wrench).
(2) Remove four cover screws.
(3) Remove cover straight forward to prevent damage to internal meter parts.
(4) Loosen screws in lower meter chassis corners.
(5) Insert fingers behind pulling lugs and pull very gently.

Reassembly is a reverse procedure. Be careful to lineup the zero adjust slotted lever with the pin when installing gasketed cover. Reinstall set point knob.



CHASSIS PANEL WITH TEST JACKS
(Use Voltmeter of 10,000 ohm Per Volt Sensitivity)

MODEL 410P WIRING DIAGRAM



DRAWING SYMBOL	DESCRIPTION OR VALUE	PART NUMBER
T1	Power Transformer	30-070-1
R1	2.2 Meg Ω, ½ W	CYZR-170-18
R2	470 Ω, ½ W	CYZR-170-32
R3	7.5 K Ω, 5 W	40-154
R4	2.5 K Ω, 3 W	40-129
R5	47 K Ω, ½ W	40-070-2
R6	1.5 Meg Ω, ½ W	40-021
R7	1 Meg Ω, ½W	CYZR-170-41
R8	1 K Ω, 3 W	CYZR-592-5
R9	470 Ω, ½ W	CYZR-170-32
R10	27 K Ω, ½ W	CYZR-170-7
R11	1 K Ω, 3 W	CYZR-592-5
R12	100 Ω, 2 W	CYZR-326-6
R13	Range Multiplier (Specify type, range and serial no.)	
R14	Neg. Temp. Coeff. Assy.	A-3049-1
R15	External Resistance Comp. Res.	A-3497
C1	8-50 MMFD, Variable	39-105
C2	22 MMFD, 500 V	39-158
C3	15 MMFD, 500 V	39-013-1
C4	.002 MFD, 600 V	39-100
C5	29-35 MMFD, Variable	39-160
C6	100 MMFD, 500 V	39-069
C7	15 MMFD, 500 V	39-013-1
C8	.01 MFD, 500 V	CYZR-220
C9	20-20 MFD, 400 V	39-156
C10	20-20 MFD, 400 V	39-156
C11	25 MFD, 25 V	39-147
C12	.05 MFD, 600 V	39-041-2
C13	25 MFD, 25 V	39-147
C14	1.5 MMFD, 600 V	39-157
D1	Sel. Rect.	37-026
D3	Sel. Rect.	37-030
L1	Osc. Coil 0.5 μh	41-120-1
L2	Choke Coil 75 μh	41-124
I1	#51 Bulb - 6.3 V	36-022-1
V1	12 AU7 Tube	EYZP-70-9

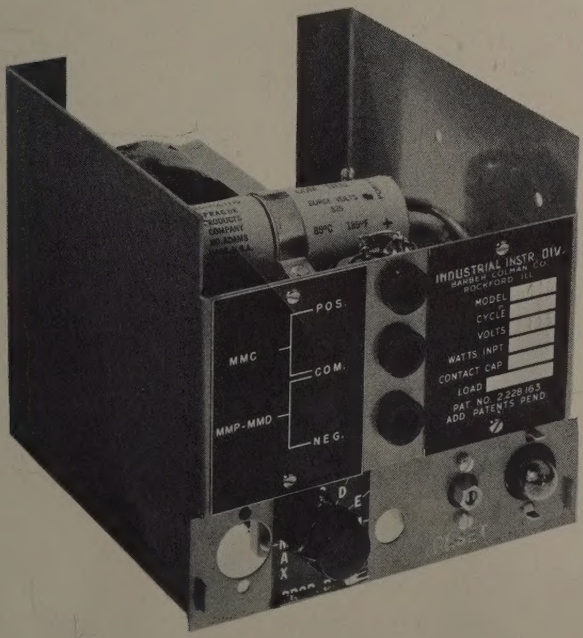
SUGGESTED REPLACEMENT PARTS

It is recommended that a few spare parts be carried by the user to insure against possible emergencies and accidental damage. We do not recommend electronic component replacement except by well equipped instrument repair shops. The following parts are recommended to be carried:

*1 Electronic tube (12AU7)	Part No. EYZP-70-9
1 Mazda pilot lamp (#51 blue bead)	Part No. 36-022-1
1 Model 410P control chassis specify by instrument serial no. and voltage	Part No. A-4242
1 Replacement thermocouple (See original order)	

*NOTE: We recommend purchase of the 12AU7 tube from the Industrial Instruments Division, Barber-Colman Company, to ensure instrument functioning as designed. These tubes are purchased under rigid specifications and tested to insure reliability.

A more rugged industrial tube is available which has a normal life in excess of 10,000 hours. Order tube No. 5814.



THERMOCOUPLES

To help you select the best thermocouples for any of your needs, two comprehensive catalogs are available to you without charge. Write to the factory or call your nearest representative.

- - For general purpose thermocouples, request Data Book and Catalog TC-13A.

- - For thermocouples used primarily in the Plastics Industry, request Catalog TC-13B.

MATERIAL WARRANTY: All equipment except tubes, photocells, and thermocouples, which within one year from date of shipment is found to have been originally defective, will be repaired (replaced if necessary) free of charge, if returned immediately, prepaid to the factory at Rockford, Illinois. The seller shall not be liable to the purchaser, or to any other person, firm or corporation for any direct, indirect or consequential damages or injury of any kind or character; that by acceptance of such equipment the purchaser shall accept and assume all liability for any and all damages or injuries that may result from the use or misuse of such equipment by the purchaser, or by any other person, firm or corporation; and that there shall be no other warranty whatever, expressed or implied, with respect to such equipment.

Warranty and Inspection Card

This equipment is guaranteed in accordance with the statement of warranty appearing on our quotation and acknowledgement forms. Upon receipt of this card properly filled out Warranty becomes effective. All Barber-Colman instruments are manufactured to the highest standards of quality and are carefully inspected before packing. Instruments which have been damaged or fail to operate upon installation, should be reported to the Factory at once.

BARBER-COLMAN COMPANY
Industrial Instruments Division

MODEL NO.
SERIAL NO.
CALIBRATION INSP.
FINAL INSPECTION

Date Received		
Company		
Street		
City	Zone	State
By		Title

COMMENTS

COPY

MP MASTER
MA32120

LITHO IN U. S. A.